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Effect of Age at Harvest and Manure or Fertilizer Application on Quality of *Vicia villosa* Roth

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Abstract: This study was conducted in Kenya over 15 weeks to determine the effect of manure or fertilizer application on quality of *Vicia villosa* Roth. After field preparation, 60 plots of 2×2 m^2 size were then demarcated and divided into 5 similar units comprising of 4 blocks of 3 plots each and independently allotted to 3 treatments in a Randomized Complete Block (RCB) design. Treatments were: T_1-control (No fertilizer), T_2 and T_3 received beef cattle manure and fertilizer, respectively. All units were planted on the same day and harvested at 6, 8, 10, 12 and 14 weeks, in a sequential manner, starting with unit 1-5. All the blocks in each unit were harvested on the same day and the entire freshly harvested materials (per plot) were weighed. Representative grab samples were collected, chopped to pieces of 2 cm length, mixed and 2 composite samples (500 g each) were then taken for dry matter determination and chemical analysis following standard procedures. Yield of nutrients was also determined. Collected data was stored in MS-Excel and analyzed using SAS. From the results it was observed that, NDF in T_1, T_2 and T_3 increased by 19.7, 14.1 and 19.2% between 6 and 14 weeks, respectively. ANOVA showed that treatment had effect on DMY (r^2 = 0.7341; $p<0.01$) at 14 weeks but not on CPY (r^2 = 0.3705; $p>0.05$). Mean ME concentration in the forage was not influenced by either manure or fertilizer application. Strong correlation between nutrients and *V. villosa* age at harvest was observed. It was therefore concluded that, though fertilization had no effect on nutrient content, it improved their overall yield.

Key words: Manure, inorganic fertilizer, dry matter, organic matter, crude protein

INTRODUCTION

Contribution of *Vicia* sp. (directly and indirectly) in crop-livestock production systems in different parts of the world is well recognized (Caballero *et al*., 2001). One attraction of vetch is its versatility, which permits diverse utilization options. In temperate climates and cooler regions in the tropics, *Vicia* sp. has been used successfully as both ruminant livestock feed and as green manure to improve soil fertility (Ennecking, 2001; Sattel *et al*., 1998). As a green manure cover crop, vetches have gained popularity for their reputed beneficial ability to fit well into cereal rotation and grass pastures. This is largely because it contributes enormously in the fixation of atmospheric Nitrogen (N) to the soil and under proper management, reduces incidences of diseases in the succeeding crops (Chowdhurry *et al*., 2001; Rathjen, 1997). This aspect is particularly relevant to smallholder resource-poor farms in Kenya, where improvement of soil fertility using inorganic fertilizers is economically not feasible (Pariyar, 2002). The value of *Vicia* sp. as protein supplement for ruminant livestock is also widely recognized (Alzueta *et al*., 2001). In many parts of the world, *Vicia* sp. is used either for grazing (fresh), hay production or harvested for its grain and straw (Chowdhurry *et al*., 2001). If harvested at the early flowering stage, all *Vicia* species are similar in nutritive value to other principal legumes (McDonald *et al*., 1984). Fresh vetch herbage is reported to have high Crude Protein (CP) level of between 16.5 and 26.5% (Hadjipanayiotou and Economides, 2001). Gohl (1981) also reported that, freshly harvested vetch forage contains about 23% CP, 29% Crude Fibre (CF) and 17% Dry Matter (DM) with CP and CF digestibility of 81 and 53%, respectively. Pinkerton and Pinkerton (2000) observed that, *Vicia sativa* hay contains about 18.4% CP, 59% Total Digestible Nutrients (TDN), 0.34% phosphorus and 0.132% calcium on DM basis. Invariably, in the East African highlands, particularly in Kenya, vetches are not grown widely despite the apparent lack of sufficient ruminant protein supplements. This is mainly attributed to the scanty information on their potential as ruminant protein supplement. This study reports findings of a study to evaluate the effect of manure or fertilizer application on quality of *Vicia villosa* Roth as one of the most potential *Vicia* species under Kenyan conditions.

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MATERIALS AND METHODS

This study was conducted at the National Animal Husbandry Research Centre in Naivasha, Kenya over a period of 15 weeks. The objective was to determine the effect of manure or fertilizer application on nutritive value of hairy vetch (*Vicia villosa* Roth). A 0.5-acre plot selected from 2.0-acre field was prepared according to recommended guidelines for establishment of sown forage pastures. After land preparation, 60 plots of 2×2 m^2 size were demarcated and further divided into 5 similar units (N = 12) comprising of 4 blocks of 3 plots each and allotted to 3 treatments in a Randomized Complete Block (RCB) design. Treatments were: T_1 – control (with neither manure nor fertilizer), T_2 and T_3 received manure and inorganic fertilizer, respectively. In T_2 and T_3, each plot received 2 kg of 5-day old cattle manure (93.17% DM, 1.711% N, 1.32% Ca and 1.12% P) and 50 g Di-Ammonium Phosphate (DAP-18: 46: 0), respectively. Manure was applied by mixing it thoroughly with top (20-30 cm thick) soil layer, whereas fertilizer was drilled with the seed. During planting, 5 rows of 2 m length, 30 cm apart and 10 cm deep were drilled on each plot and a total of 10 g of seed were sown with each row receiving exactly 2 g of seeds (80% viability). All the plots in the five units (N = 60) were planted on the same day and harvested at 6, 8, 10, 12 and 14 weeks in a sequential manner beginning with unit 1-5. Within each unit, guard rows of 30 and 60 cm between plots and blocks, respectively. Both plots and guard rows were kept weed free throughout the trial. During each harvest, all the freshly harvested materials (per plot) were weighed using field-weighing scale (50 kg). Representative grab samples were collected (per plot), chopped to pieces of 2 cm length, mixed thoroughly and 2 composite samples (500 g each) were taken for Dry Matter (DM) determination and chemical analysis. DM was determined by oven drying at 105°C for 24 h (AOAC, 1990). Ash content was determined by ashing in a muffle furnace at 550°C (AOAC, 1990). Crude Protein (CP) was determined through the kjeldahl method (% N×6.25). Cell wall components were determined according to Van Soest *et al*. (1994) and Abdulrazak and Fujihara (1999). Nutrient degradation characteristics were measured (using the nylon bag technique) as described by Ørskov *et al*. (1980) and Ørskov and McDonald (1979). Hectare Dry Matter Yield (DMY), Organic Matter Yield (OMY) and Crude Protein Yield (CPY) were also determined. Metabolizable energy (ME MJ kg^{-1} DM) was determined as described by Menke and Steingass (1988). Using the average ME calculated, ME Yield (MEY) per ha was determined. The collected data was stored in MS-Excel and analyzed using appropriate SAS (2002). Analysis of Variance (ANOVA) to determine effect of treatment on study parameters (DMY, OMY, CPY, ME and MEY) was done. The statistical model applied was $Y_{ij} = \mu + C_i + T_j + C_i * T_j + e_{ij}$; where Y_{ij} is DMY, OMY and CPY (kg DM $4m^{-2}$ translated to Ton ha^{-1}), μ is the overall mean, C_i is age at harvest in weeks (i = 6, 8, 10, 12, 14), T_j is treatment (j = 1, 2, 3), $C_i * T_j$ is age at harvest and treatment interaction and e_{ij} is the standard error. Parameter yield means were compared using General Linear Model (GLM) procedure of SAS (2002).

RESULTS

Results revealed that the actual dry matter content in *Vicia villosa* Roth remained low throughout the study period. Between 6 and 14 weeks, the air DM in the forage increased by 61.8% from 121.7-196.9 g kg^{-1} DM in T_1. The mean air DM in T_2 and T_3, were also observe to fall in the same range. NDF content in T_1, T_2 and T_3 increased by 19.6, 14 and 19.2% from 321.7, 330.7, 319.7 at 6 weeks to 384.9, 376.4, 381.1 g kg^{-1} DM at 14 weeks, respectively. The increase in NDF represented accumulation rate of 1.13, 0.83, 1.1 g kg^{-1} DM d^{-1} in the 3 treatments, respectively. ADF and ADL concentration across the 3 treatments also, showed upward trend over the study period. As expected, results showed that, *Vicia villosa* has a high CP concentration. At 6 weeks, the mean CP content in T_1, T_2 and T_3 were 204.4, 202.4 and 200.5 g kg^{-1} DM, respectively. Interestingly however, results further showed that CP concentration in this forage increased with advancing forage maturity. The 3 treatments recorded 36.1, 31.2 and 23% increases in CP concentration between 6 and 14 weeks, respectively. Ether extract, however, declined by 69.1, 62.3 and 64.7% from 62.1, 59.1, 65.7 g kg^{-1} DM at 6 weeks to 19.2, 22.3, 23.2 g kg^{-1} DM at 14 weeks in the 3 treatments, respectively. Though, DMY and OMY values in T_3 at 6 weeks were numerically higher than T_1 and T_2, Analysis of Variance (ANOVA) showed that treatment had no significant effect on DMY ($r^2 = 0.0769$; $p>0.05$) and OMY ($r^2 = 0.4796$; $p>0.05$). At 14 weeks however, differences between treatments were evident with T_1 recording 14.8 and 26% lower DMY than T_2 ($p<0.05$) and T_3 ($p<0.05$), respectively. Results also showed that DMY increased significantly over the 14-week study period. Between 6 and 14 weeks, T_1, T_2 and T_3 recorded DMY and OMY accumulation rates of 64.9, 75, 81.6 g and 49.6, 56.9, 61.9 g $4m^{-2}$ d^{-1}, respectively. ANOVA showed that manure or fertilizer application had significant effect on DMY ($r^2 = 0.7341$; $p<0.01$) and OMY ($r^2 = 0.7577$; $p<0.01$) of *Vicia villosa* at 14 weeks. Effect of manure or fertilizer was also evident at 8, 10 and 12 weeks. Treatment had no significant effect on CP concentration

Table 1: Metabolizable Energy (ME) content and Yield (MEY) of *Vicia villosa* harvested at different maturity stages

	AAH	Control (T_1) Means±S.E	Manure (T_2) Means±S.E	Fertilizer (T_3) Means±S.E	ANOVA R^2	P	CV
ME ($MJ\ kg^{-1}$ DM)							
	6	9.33^{a}±0.17	9.63^{a}±0.21	9.63^{a}±0.18	0.5141	0.0389	3.95
	8	9.19^{a}±0.13	9.31^{a}±0.08	9.27^{a}±0.02	0.0685	0.7266	1.94
	10	8.76^{a}±0.08	8.83^{a}±0.34	8.87^{a}±0.12	0.0159	0.9301	4.72
	12	8.51^{a}±0.37	8.66^{a}±0.61	8.54^{a}±0.41	0.0061	0.9733	11.11
	14	8.61^{a}±0.28	8.44^{a}±0.26	8.37^{a}±0.08	0.2707	0.2415	20.52
ME yield ($MJ\ ha^{-1}$)							
	6	4.20^{a}±0.43	4.41^{b}±0.13	5.78^{c}±0.61	0.4983	0.0449	18.45
	8	21.43^{a}±1.41	24.67^{ab}±0.61	27.46^{b}±2.09	0.4729	0.0561	12.25
	10	47.69^{a}±2.69	55.22^{ab}±1.97	61.55^{b}±3.12	0.6066	0.0152	9.61
	12	64.76^{a}±6.01	80.44^{b}±8.99	83.67^{b}±8.17	0.2707	0.2415	20.52
	14	81.84^{a}±1.57	92.21^{b}±4.11	100.51^{b}±2.79	0.6819	0.0058	6.58

ME ($MJ\ kg^{-1}$ DM) = $2.20 + 0.136*GP + 0.057*CP + 0.0029*(CP)^2$ as described by Menke and Steingass (1988); GP-24 h *in vitro* gas production, CP-Crude Protein; ME yield (MJ) = DMY*ME (Muia *et al.*, 2000)

Table 2: Effect of age and treatment on *in sacco* nutrient degradability (P = a + b (1 – e^{-ct}; Ørskov and McDonald, 1979) of *Vicia villosa*

		24 h incubation			36 h incubation		
Nutrient	AAH	T_1	T_2	T_3	T_1	T_2	T_3
Dry Matter (%DMD)							
	6	72.02	77.41	74.39	78.71	80.91	78.54
	10	67.58	70.68	68.86	73.84	80.27	75.36
	14	66.91	62.79	66.78	69.68	79.87	73.26
Organic Matter (%OMD)							
	6	71.75	75.91	72.43	77.21	79.65	75.55
	10	63.23	66.83	62.31	68.82	77.74	73.48
	14	60.41	55.21	60.37	67.56	76.29	70.23
Crude Protein (%CPD)							
	6	83.15	83.4	80.08	88.81	88.61	86.75
	10	82.07	78.64	78.47	85.41	86.79	83.37
	14	77.34	74.65	76.37	82.18	86.56	82.95

Aah-Age At Harvest in weeks

Table 3: Yield of digestible nutrients based on 24 h *in sacco* degradability (P = a + b (1 – e^{-ct}; Ørskov and McDonald, 1979)

		Mean Yield ($kg\ 4m^{-2}$)			Mean Yield ($ton\ ha^{-1}$)		
Nutrient	AAH	T_1	T_2	T_3	T_1	T_2	T_3
Digestible Dry Matter (DDM)							
	6	0.130^{a}	0.141^{a}	0.177^{b}	0.324^{a}	0.354^{a}	0.445^{b}
	10	1.472^{a}	1.771^{b}	1.911^{b}	3.681^{a}	4.421^{b}	4.781^{b}
	14	2.552^{a}	2.751^{b}	3.209^{c}	6.379^{a}	6.874^{ab}	8.024^{b}
Digestible Organic Matter (DOM)							
	6	0.106^{a}	0.114^{a}	0.139^{b}	0.262^{a}	0.283^{a}	0.342^{b}
	10	0.988^{a}	1.191^{b}	1.223^{b}	2.472^{a}	2.977^{ab}	3.058^{b}
	14	1.767^{a}	1.841^{a}	2.209^{b}	4.413^{a}	4.602^{a}	5.528^{c}
Digestible Crude Protein (DCP)							
	6	0.029^{a}	0.031^{ab}	0.042^{b}	0.075^{a}	0.075^{a}	0.101^{b}
	10	0.453^{a}	0.499^{ab}	0.545^{b}	1.131^{a}	1.245^{ab}	1.358^{b}
	14	0.821^{a}	0.866^{ab}	0.936^{b}	2.044^{a}	2.169^{ab}	2.342^{b}

AAH-Age At Harvest in weeks, Means with the same superscript ($^{a, b, c}$) within the same row under same sub-heading are not significantly different

in the herbage. Dry matter, OM and CP rumen degradability as influenced by both treatment and age at harvest were also investigated (Table 1). Results showed that major part of DM, OM and CP in *Vicia Villosa* was degraded within the first 24 h of rumen incubation (Table 2).

Results showed that DM, OM and CP degradability was inversely related to the age at harvest, across the 3 treatments. Between 6 and 14 weeks DM, OM and CP degradability rates at 24 h incubation period, declined marginally by T_1: 5.11, 11.34 and 5.81%; T_2: 14.62, 20.7 and 8.75% and T_3: 7.61, 12.06 and 3.71% respectively. From the results it was noted that CP degradability was significantly higher than that of DM and OM at the same incubation time and stage of harvest. Using the recorded rumen degradability rates, yields of degradable DM, OM and CP in the 3 treatments, at $2\times2\ m^2$ plot and ha level, as influenced by advancing forage maturity, were calculated (Table 3). The observed DDMY increases between 6 and 14 weeks, represented accumulation rates of 43.25, 46.61

and 54.14 g 4m^{-2} d^{-1} for the 3 treatments, respectively. The same trend was also observed with DOMY and DCPY. Results showed that T_1, T_2 and T_3 recorded DOMY and DCPY accumulation rates of 29.7, 30.8, 37 and 14.1, 14.9, 16 g 4 m^{-2} d^{-1} between 6 and 14 weeks, respectively. Results further showed that DOMY and DCPY in T_1 and T_2 were not significantly different (p<0.05). Compared to T_1, however, T_3 recorded significantly higher DOMY and DCPY (Table 3). Concentration and yield of Metabolizable Energy (ME) was also examined (Table 1).

From the means presented in Table 1, it can be seen that, neither manure nor fertilizer had effect on ME concentration in *Vicia villosa* as evidenced by Analysis of Variance (ANOVA). There was however, a decline in ME concentration with advancing age of the forage with T_1, T_2 and T_3 recording 7.7, 12.4 and 13.1% drop between 6 and 14 weeks, respectively. Results further revealed that, despite the downward trend in ME concentration, the overall ME yield increased with advancing forage age. The 3 treatments recorded ME accumulation rates of 1.39, 1.57 and 1.69 MJ ha^{-1} d^{-1}, respectively. It was also observed that, in terms of ME yield, differences between treatments were evident. At 14 weeks the ME yield in T_2 and T_3 were significantly higher compared to T_1 (p<0.05).

DISCUSSION

Results demonstrated that nutrient digestibility and cell wall, protein and metabolizable energy content in *Vicia villosa*, are favorable when considered in the context of their suggested critical limits and their known interdependence in ruminant diets (Van Soest, 1982; Mertens, 1994; Wieland, 2002). These authors asserted that energy and protein are the primary nutritional requirements of all classes of animals. These requirements must be met (energy first, protein second) before requirements for other nutrients (minerals and vitamins) are addressed. The protein value of ruminant feeds is affected by amount, form and quality of proteins. Form here refers mainly to the ease with which dietary protein is ingested by rumen fermentation and is influenced by solubility. The energy value of ruminant feeds is greatly affected by their fibre content because this is inversely related to digestibility. Low energy value feed impairs efficiency of protein utilization. Thus, insufficient fermentable energy limits the rate of microbial growth and ability to synthesize microbial protein, regardless of the level of dietary protein. This, in turn limits rates of fermentation and therefore, voluntary intake. The cell wall content and their magnitude and nature of lignifications are amongst the most important intrinsic factors, which govern the degradability and the rate of passage of forage. The recorded mean NDF concentration in T_1, T_2 and T_3 at 14 weeks were far below the critical limit of 600 g kg^{-1} DM reported to inhibit feed intake (Van Soest, 1982), indicating that *Vicia villosa* Roth is a low fibre forage. The obtained CP values also compared well with the 190-240 g kg^{-1} DM reported by Gohl (1981). The noted upward trend of CP concentration observed was largely attributed to the rapid pod filling and seed formation (Caballero *et al*., 2001). Results showed that DM, OM, CP and ME concentration in *Vicia villosa* was not influenced by either manure or fertilizer application. ANOVA however, revealed that their yields were significantly affected by soil fertilization. This was attributed to the positive effect of both N and minerals applied on the biomass yield, which in turn increased the overall quantity of these nutrients. When examining the effect of advancing maturity on forage degradability, it was observed that, forage harvested at 6 weeks recorded DM, OM and CP degradability rates (at 24 h incubation) compared to that harvested at 14 weeks. Gohl (1981) reported CP digestibility of 81% in vetch, which compared well with the findings of this study. However, the 89% DM digestibility reported by the same author was slightly higher than that observed in the current study. The comparatively higher degradability rates of 6-week old *Vicia villosa* material, as observed were largely attributed to the low fibre content at this age. From the results, it was also noted that, ME concentration in *Vicia villosa* remained generally high throughout the study period.

CONCLUSION

Results demonstrated that, though manure or fertilizer application had little effect on nutrient concentration, it improved their overall yields. It was therefore, concluded that manure or fertilizer application would not have tangible effect on quality of *Vicia villosa* Roth. However, if the primary objective is to enhance biomass yield, then manure or fertilizer application would be worthwhile, particularly in low N soils.

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